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(54) Title: METHOD AND ARRANGEMENT FOR REVERSING A VEHICLE

(57) Abstract

The invention relates to a method and an apparatus for reversing a vehicle, especially a vehicle combination. The method comprises imaging of the reversal area with a video camera from the rear part of the vehicle backwards, transmitting the pictures of the reversal area to the driver in the driver's cab in the vehicle, and the driver carries out reversal of the vehicle by monitoring the picture information and steering the vehicle accordingly. In accordance with the invention, a reversal steering device (9) is provided in the driver's cab of the vehicle for determining the desired reversal path, especially the curvature of the reversal path; a computing program stored in a data processing unit (13) determines the desired directional angle of the steerable wheels (3), which allows the desired reversal path to be achieved; the reversal steering operations are carried out as a continuous closed–loop control process, while determining the mutual positions of the vehicle combination and the directional angle of the steerable wheel, the directional angle being adjusted towards the desired calculated directional angle in order to achieve the desired reversal path.

Method and arrangement for reversing a vehicle

The invention relates to a method as defined in the preamble of claim 1 for reversing a vehicle, especially a vehicle combination.

5   The invention also relates to an arrangement as defined in the preamble of claim 3 for reversing a vehicle, especially a vehicle combination.

A conventional arrangement for easier reversal of a vehicle is previously known, in which a video camera equipped with a hatch and directed backwards is embedded in the rear of the vehicle, and a display is provided in the driver's cab in the immediate

10   vicinity of the driver. The hatch is adapted to open and the camera to operate when the reverse gear is switched on. The camera transmits an image of the vehicle from the rear backwards to the driver, who can thus reverse the vehicle by watching the video picture shown on the display.

The conventional arrangement has the same drawback as normal reversal, i.e. it

15   requires good vehicle control of the driver. The reversal of a vehicle combination in particular is an operation that takes much practice to become effortless for the driver.

The object of the invention is to eliminate the drawbacks connected with the conventional arrangement described above, and with vehicle reversal in general.

20   Another object of the invention is to provide a new method and arrangement for carrying out the reversal of a vehicle.

The method of the invention is characterised by the features defined in claim 1. The apparatus of the invention is characterised by the features defined in claim 3. The dependent claims describe preferred embodiments of the invention.

25   In the method of the invention for reversing a vehicle, especially a vehicle combination, the reversing area is imaged from the rear of the vehicle backwards, pictures of the reversing area is transmitted to the driver in the driver's cab of the vehicle, and the driver carries out the reversal of the vehicle by monitoring the picture information and steering the vehicle accordingly. In the method of the

30   invention:

- the driver's cab in the vehicle is provided with a reversal steering device for determining the desired reversal path, especially the curvature of the reversal path;

- using a computing program stored in a data processor the desired directional angle of the steerable wheels is determined, and with the aid of this angle the desired reversal path can be achieved; and

- the reversal steering operations are performed as a continuous closed-loop control
5 process, during which the position of the parts of the vehicle combination is determined, such as their mutual articulation angle and the directional angle of the steerable wheel, the directional angle being adjusted towards the desired calculated directional angle in order to follow the desired reversal path.

The invention has the advantage of allowing a vehicle, especially a vehicle
10 combination, such as an articulated lorry, to be steered by means of the reversal steering device, while utilising the data processing unit and the program stored in this, just as if the driver's cab were at the rear of the vehicle and the vehicle were driven forwards viewed from the display. This arrangement makes it appreciably easier for the driver to carry out the reversal steering operations, because the vehicle
15 is virtually moved as though it were a forward movement. In other words, the driver is transferred to the rear of the vehicle by means of computing means.

The method and the apparatus of the invention is applicable also to vehicle combinations articulated at two points.

The invention is described in detail below with reference to the accompanying
20 drawing, in which

figure 1   is a schematic top view of a vehicle combination formed of a drawing vehicle and a trailer;

figure 2A   is a schematic view of the first part of the apparatus of the invention, comprising a video camera and a display;

25 figure 2B   is a schematic view of a block diagram of the second part of the apparatus of the invention; and

figure 3   is a principal block diagram of the computation of the steering operations.

The invention is schematically described below with the aid of the vehicle
30 combination schematically shown in figure 1. This vehicle combination comprises a drawing vehicle 1 and a trailer 2, which are pivoted to each other at the articulation point KN. The drawing vehicle 1 comprises a turnable front wheel 3 (or optionally

3

two mutually spaced front wheels) and rear wheels 4 directed in the longitudinal direction of the drawing vehicle. The trailer 2, in turn, comprises rear wheels 5, such as a trailing bogie, with its wheels directed in the longitudinal direction of the trailer.

5   The apparatus of the invention, figure 2A, comprises means of imaging, such as a video camera 6, which is disposed at the rear of the vehicle, in this case in the rear 2a of the trailer 2, with a view to monitor the reversal area. It is then directed from the rear part of the trailer 2 backwards, preferably parallel to the central line KN-K3 of the trailer 2. This requires a video camera 5 with relatively wide-angle optics to

10   ensure a visual range with adequate amplitude and width. The video camera 6 is preferably fitted into a space 8b which can be closed with a hatch 8a. The display 7, preferably a video monitor, is disposed in the driver's vicinity in the driver's cab of the drawing vehicle 1. The video camera 6 and the display 7 are interconnected over a suitable signal path 15, such as a cable or a wireless radio line. The driver

15   monitors the pictures generated by the video camera 6 on the display 7 and makes use of it when reversing the vehicle combination 1, 2 as explained below.

The apparatus of the invention, figure 2B, also comprises a reversal steering device 9, an angular sensor 10 of the steerable wheel 3, an articulation sensor 11, a turning device 12 and a data processing unit 13. Using the steering device 9, the driver gives

20   the actual control commands, i.e. the reversal path. The directional angle α of the steerable wheel 3 is provided by the angle sensor 10 connected to the wheel. The articulation angle β of the mutually pivoting vehicle parts 1, 2 is provided by the articulation sensor 11. The turning device 12 is intended to turn the steerable wheel 3, i.e. to alter its directional angle α.

25   The data processing unit 13 is fed with a control command from the reversal steering device 9, wheel directional angle data α from the angle sensor 10 of the steerable wheel 3 and, similarly, with the articulation angle β of the vehicle combination from the articulation sensor 11, the data being processed with a computing program stored in the data processing unit 13. The operation is based on

30   the desired reversal path provided by the reversal steering device 9, and it is realized by repeatedly adjusting the directional angle α of the steerable wheel 3, at suitably short intervals, to the computed directional angle α_{ref}, so that during the reversal, the vehicle moves into the desired direction exactly as desired.

The apparatus of the invention also comprises a reversal safety sensor 14. By means

35   of this sensor, the apparatus of the invention for reversing a vehicle is activated, i.e.

switched on, when the reversing gear or similar is switched on. In any other situation, the apparatus is in a passive, i.e. inoperative state.

The reversal steering device 9 is preferably a mini-steering wheel placed in the vicinity of the actual steering wheel 15 in the driver's cab of the vehicle. The

5   reversal is given the desired path with the aid of the the turning angle of the mini-steering wheel or a similar steering command representing reversal direction data. The steering command is forwarded in electronic form to the data processing unit 13.

The turning device 12 for turning the steerable wheel 3 of the vehicle is preferably a

10   stepping motor, which is connected over a suitable transmission device e.g. to the steering wheel 15, such as its pivot axle 15a, for mechanical turning of the wheel 3, i.e. for altering its directional angle α.

The data processing unit 13 is a micro-processor or similar, including suitable storage and interface units. A program has been stored in its memory unit to control

15   the reversal steering operations in a continuous closed-loop control process, during which the mutual positions of the parts 1, 2 of the vehicle combination are determined, such as the articulation angle β, and the directional angle α of one or two steerable wheels, and the desired directional angle α_{ref} of the steerable wheel is determined on the basis of the desired reversal path, and the achievement of this

20   angle is sought with subsequent operations. The control commands given by the driver with the steering device 9 in order to carry out the reversal are processed with the computing program so as to result in control signals, which are fed to the turning device 12, such as a stepping motor, by means of which the steering angle α of the one or two steerable wheels 3 is altered towards the desired computed steering angle

25   α_{ref} so that the desired steering process, i.e. the reversal path is achieved. The physical properties of the vehicle combination, such as its dimensions, are constants in the computing program.

The method and apparatus of the invention use the data processing unit 13 and the computing program stored in this for computing the desired directional angle α_{ref} of

30   the steerable wheel 3 and for achieving the real directional angle α so that the vehicle combination 1, 2 will follow the desired path backwards, and especially virtually as though the driver were steering the vehicle combination forwards with regard to how he carries out the steering operations.

5

Figure 3 shows the basis of the steering operations. A computing program has been stored in the data processing unit 13. In the initial situation, the reversing gear of the vehicle is assumingly switched on. The mutual position of the drawing vehicle 1 and the trailer 2 of the vehicle is determined with the aid of data provided by the angle

5   sensors, especially the articulation sensor 11. This arrangement provides information about the articulation angle β between the longitudinal axes of the drawing vehicle 1 and the trailer 2. The driver gives the desired curvature for the trailer path by means of a reversal steering device 9, such as a mini-steering wheel. This curvature corresponds to the desired path of the rear of the trailer 2 in the

10   vehicle combination. The desired directional angle α_{ref} of the steerable wheel 3 is calculated at the beginning of and during the reversal on the basis of the mutual positions of the drawing vehicle 1 and the trailer 2.

When the desired directional angle α_{ref} of the steerable wheel 3 has been calculated, the directional angle α of the wheel is adjusted accordingly (or at least towards the

15   desired angle) with the turning device 12, and the vehicle is reversed. The position of the vehicle is repeatedly calculated during the reversal and the operations described above are repeated. The desired new directional angle α_{ref} of the steerable wheel is calculated and carried out by means of the turning device 12. The path settings for the reversal steering device 9 are read and the computing operations are

20   both carried out at suitably short intervals, such as e.g. 10 times per second.

The computing program stored in the data processing unit 13 is preferably based on the following definitions. The longitudinal central axis of the drawing vehicle 1 in the vehicle combination passes through the points K1 - K2 - KN, and the longitudinal central axis of the trailer 2 passes through the points KN - K3. Thus the

25   central axes pass through the articulation point KN (x_n, y_n), which is determined in the rectangular xy co-ordinate system. The distance between the centre K1 of the front wheel 3 of the drawing vehicle 1 and the centre K2(x_a, y_a) of the axis between the rear wheels 4 is L. The distance between the articulation point KN and the centre K2 of the axis between the rear wheels of the drawing vehicle is S.

30   Accordingly, the distance between the centre K3(x_p, y_p) of the axis between the rear wheels 5 of the trailer 2 and the articulation point KN is P. The axial width of both the trailer 2 and the drawing vehicle 1 is twice the length H. The direction of the central axis of the drawing device 1 is represented by the symbol δ_a and the direction of the central axis of the trailer 2 accordingly with the symbol δ_p.

35   The computing program is based on the following operations. The position of the drawing vehicle 1 is determined with the aid of the point K2 and the direction δ_a of

6

the central axis of the drawing vehicle. The position of the trailer 2 is estimated with the aid of the position of the drawing vehicle 1 and the articulation angle β. The trailer has the following position:

$$x_p = x_a - S \cdot \cos\delta_a - P \cdot \cos(\delta_a + \beta) \tag{1}$$

5

$$y_p = y_a - S \cdot \sin\delta_a - P \cdot \sin(\delta_a + \beta) \tag{2}$$

$$\delta_p = \delta_a + \beta + \pi \tag{3}$$

Using the path deviation and the positional error of the trailer, the reference curvature, i.e. the desired reversal path is calculated for the trailer. When the trailer 2 is moved backwards in the direction of the desired curvature, the articulation point

10   moves on a curve with congruent centre, the centre being:

$$x_{kp} = x_p + \frac{1}{K_{pref}} \cdot \cos\left(\delta_p + sign(\kappa_{pref}) \cdot \frac{\pi}{2}\right) \tag{4}$$

$$y_{kp} = y_p + \frac{1}{K_{pref}} \cdot \sin\left(\delta_p + sign(\kappa_{pref}) \cdot \frac{\pi}{2}\right) \tag{5}$$

Then the desired direction of movement of the articulation point KN in the world system of co-ordinates is obtained in the direction of the normal and then in that of

15   the tangent:

$$\theta_{vn} = \text{atan}\,2\left(y_n - y_{kp}, x_n - x_{kp}\right) + sign(\kappa_{pref}) \cdot \frac{\pi}{2} \tag{6}$$

The desired reversal direction of the vehicle combination is represented by the reference curvature K_{pref}.

In the co-ordinate system of the drawing vehicle 1, the difference between its frame

20   and the desired direction of movement of the articulation point KN corresponds to the following formula 7. It should, of course, be parallel with the reversing movement.

$$\phi_{rv} = \delta_a - \theta_{vn} \tag{7}$$

The directional angle $\alpha = \alpha_{ref}$ is calculated for the steerable wheel, and by means of

25   this the reversal path is carried out:

$$\alpha = \arctan\left(-\frac{L}{S} \cdot \tan\phi_{rv}\right) \tag{8}$$

It should be noted that if S = 0, the computation will not work in this form. In that case, one has either to accept path errors for the trailer 2, or change the position of the drawing vehicle 1 by driving with the directional angle α = 90 degrees of the wheel 3. In this way, the articulation point KN of the wheel will follow the desired curvature. Other limitations are caused by large lateral movements of the trailer and by the trailer hitting the connecting rod as the articulation angle increases.

The service reliability of the apparatus of the invention is guaranteed by means of the reversal safety sensors 14. The apparatus can be used only when the reversing gear of the vehicle is activated. In this situation, the function of the turning device 12 is impeded, or optionally, such a weak motor is provided in the turning device 12 that the driver can turn the steering wheel in any situation.

The invention is not restricted to the embodiment example above alone, other modifications being conceivable without departing from the scope of the inventive idea defined in the claims. It should be noted that the computing method described above, though compact and offering computing efficiency, is but one of several conceivable mathematical methods for calculating the directional angle of steerable wheels on the basis of a desired reversal path.

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Claims

1.   A method for reversing a vehicle, especially a vehicle combination, comprising

- imaging of the reversing area from the rear part of the vehicle backwards;

- transmitting the pictures of the reversing area to the driver in the driver's cab of
5   the vehicle; the driver carries out reversal of the vehicle by monitoring the picture
information and steering the vehicle accordingly,

characterised in that the method comprises

- providing a reversal steering device (9) in the driver's cab of the vehicle in order to
determine the desired reversal path, especially the curvature of the reversal path;

10   - determining with a computing program stored in a data processing unit (13) the
desired directional angle (α_{ref}) of the steerable wheels (3), and this angle allows the
desired reversal path to be achieved; and

- performing the reversal steering operations as a continuous closed-loop control
process, while determining the mutual positions of the parts (1, 2) of the vehicle
15   combination and the directional angle (α) of the steerable wheel, the directional
angle being adjusted towards the desired calculated directional angle (α_{ref}) in order
to achieve the desired reversal path.

2.   A method as defined in claim 1, **characterised** in that the dimensions (L, S, P)
of the vehicle combination, such as of the drawing vehicle (1) and of the trailer (2),
20   and one or more articulation angles (β) between these, are utilised to calculate the
mutual positions of the parts (1, 2) of the vehicle combination.

3.   An apparatus for reversing a vehicle, especially a vehicle combination,
comprising:

- means of imaging (6) such as a video camera, which is disposed in the rear of the
25   vehicle to monitor the reversing device;

- a display (7) such as a video monitor, which is disposed in the vicinity of the
driver in the driver's cab of the vehicle, the pictures produced with the means of
imaging being monitored and utilised in the reversal of the vehicle,

characterised in that the apparatus further comprises:

- a reversal steering device (9) for providing the desired trailer path acting as a control command for the reversal;

- an angle sensor (10) of the steerable wheel (3) of the vehicle for determining the directional angle (α) of the wheel;

- an articulation sensor (11) for determining the articulation angle (β) between the central axes of the turning parts (1, 2) of the vehicle;

- a turning device (12) for turning the steerable wheels (3); and

- a data processing unit (13) for receiving control commands i.e. directional and articulation angle data (α,β), from the reversal steering device (9), and for processing them with the computing program, the reversal steering operations being carried out as a continuous closed-loop control process, while determining the mutual positions of the parts (1, 2) of the vehicle combination and the directional angle (α) of the steerable wheel, the directional angle being adjusted with the turning device (12) towards the desired calculated directional angle (α_{ref}) in order to achieve the desired reversal path.

4.   An apparatus as defined in claim 3, **characterised** in that the apparatus further comprises a reversal safety sensor (14).

5.   An apparatus as defined in claim 3 or 4, **characterised** in that the reversal steering device (9) is a mini-steering wheel.

6.   An apparatus as defined in claim 3, 4 or 5, **characterised** in that the turning device (12) for turning the steerable wheels (3) is a stepping motor.

FIG. 1

FIG. 2A

FIG. 2B

3/3

```
        ┌─────────────┐
        │    START    │
        └──────┬──────┘
               │
               ▼
  ┌──────────────────────────┐
  │  READ POSITION OF VEHICLE │
  │  AND DESIRED REVERSAL     │
  │  ANGLE OF TRAILER         │
  └──────────────────────────┘
               │
               ▼
  ┌──────────────────────────┐
  │  CALCULATE DIRECTIONAL    │
  │  ANGLE OF STEERABLE       │
  │  WHEELS                   │
  └──────────────────────────┘
               │
               ▼
  ┌──────────────────────────┐
  │  ADJUST DIRECTIONAL ANGLE │
  │  OF STEERABLE WHEELS      │
  │  TO CALCULATED VALUE      │
  └──────────────────────────┘
               │
               ▼
  ┌──────────────────────────┐
  │  REVERSE THE VEHICLE      │
  └──────────────────────────┘
               │
               ▼
         ◇ REVERSAL      NO
         ◇ COMPLETED? ◇───────►
               │
               │ YES
               ▼
        ┌─────────────┐
        │     END     │
        └─────────────┘
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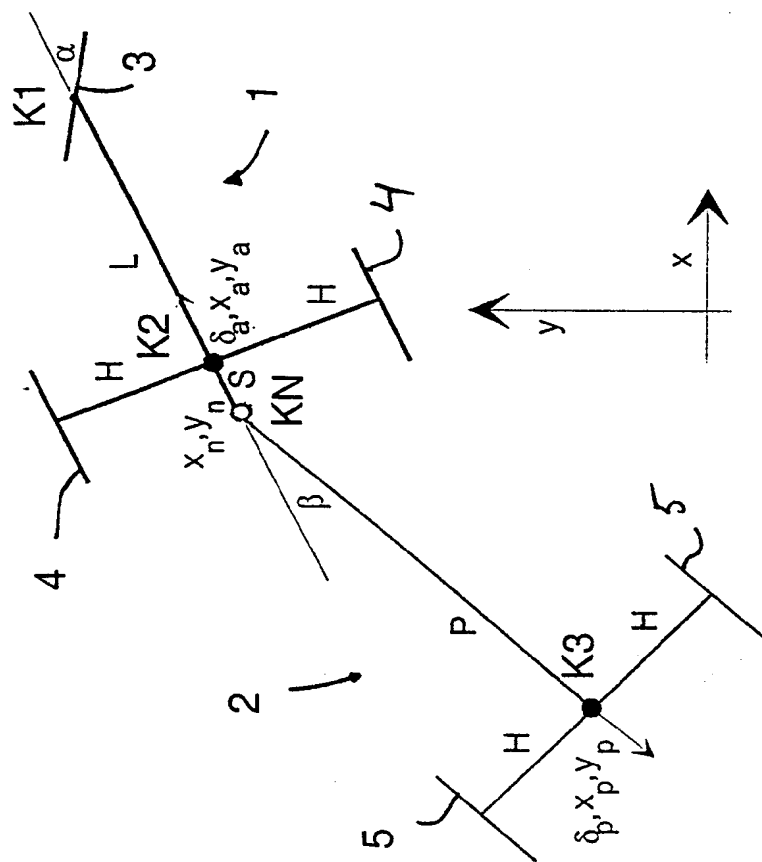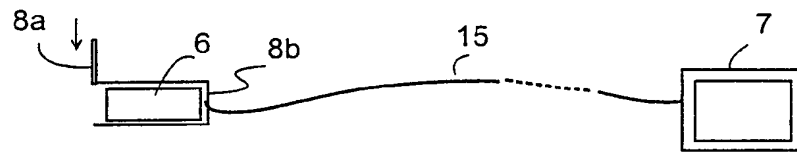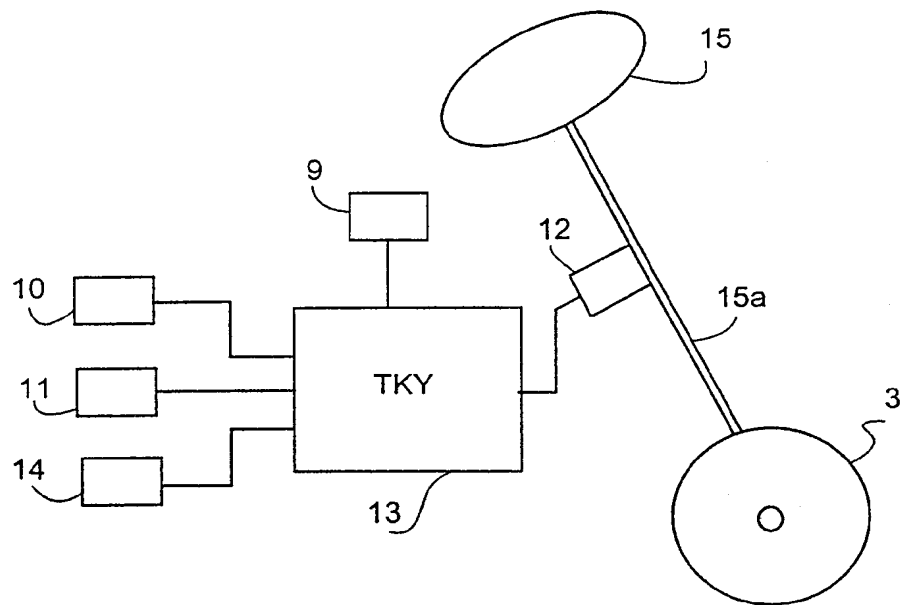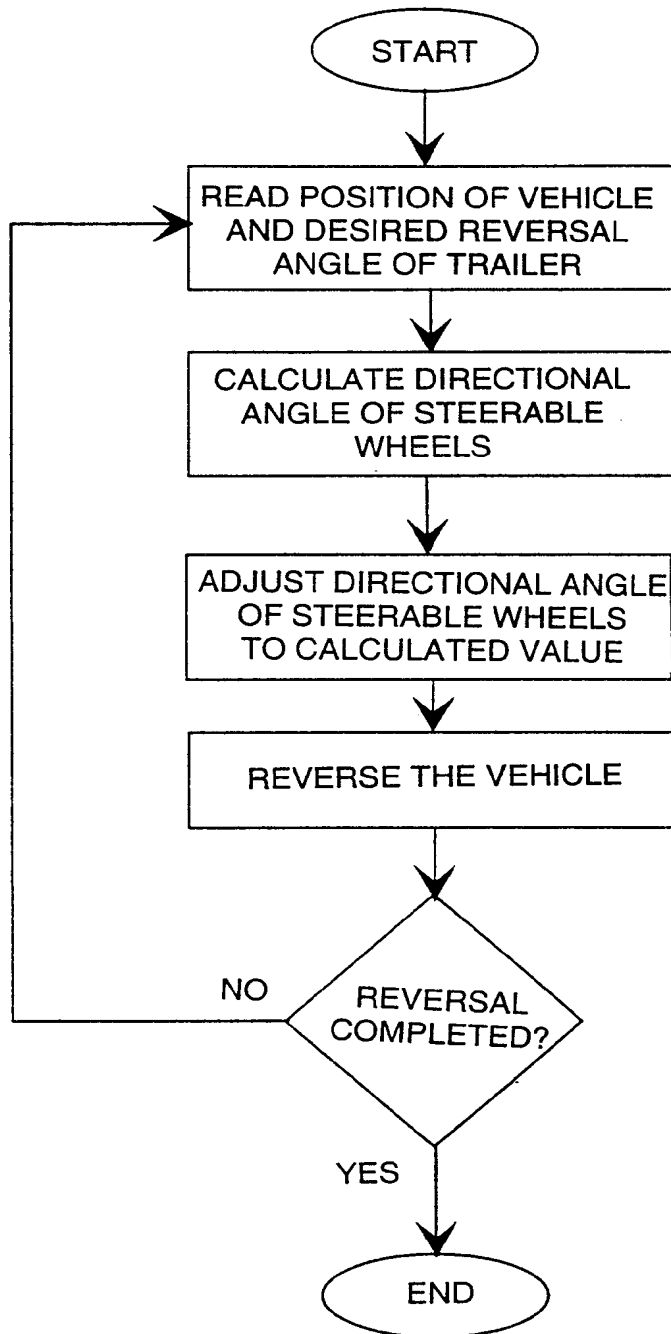
FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 00/00050

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: B62D 13/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: B62D, G05D, B60R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 8503263 A1 (S. MARTINET), 1 August 1985 (01.08.85), see the whole document	1-6
X	DE 19526702 A1 (H.J. ROOS ET AL.), 6 February 1997 (06.02.97), see the whole document	1-6
X	DE 3923676 A1 (GEORG FISCHER FAHRZEUGTECHNIK GMBH), 24 January 1991 (24.01.91), see the whole document	1-6
X	FR 2515379 A1 (A. CLERC), 23 October 1981 (23.10.81), see the whole document	1-6

[X] Further documents are listed in the continuation of Box C.   [X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
21 June 2000	2 2 -06- 2000

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI 00/00050

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4277804 A (E. ROBISON), 7 July 1981 (07.07.81), abstract --	1-6
A	US 5247442 A (R.G. KENDALL), 21 Sept 1993 (21.09.93), abstract --	1-6
A	EP 0849144 A2 (HONDA GIKEN KOGYO KABUSHIKI KAISHA), 24 June 1998 (24.06.98), abstract --	1-6
A	US 5579228 A (S.S. KIMBROUGH ET AL.), 26 November 1996 (26.11.96), abstract -- --------	1-6

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
WO 8503263 A1	01/08/85	AT 41126 T		15/03/89
		AU 3781885 A		09/08/85
		BR 8407269 A		24/12/85
		CH 655471 B		30/04/86
		EP 0168411 A,B		22/01/86
		SE 0168411 T3		
		ES 539672 A		01/04/86
		IT 1181850 B		30/09/87
		IT 8547544 D		00/00/00
		JP 61500903 T		08/05/86
		CH 660711 A,B		15/06/87
		AT 61298 T		15/03/91
		EP 0239592 A,B		07/10/87
		SE 0239592 T3		
		FR 2587962 A		03/04/87
		JP 63501067 T		21/04/88
		US 4848499 A		18/07/89
		WO 8701999 A		09/04/87
DE 19526702 A1	06/02/97	NONE		
DE 3923676 A1	24/01/91	CH 683086 A		14/01/94
FR 2515379 A1	23/10/81	NONE		
US 4277804 A	07/07/81	NONE		
US 5247442 A	21/09/93	NONE		
EP 0849144 A2	24/06/98	JP 2952816 B		27/09/99
		JP 10167103 A		23/06/98
US 5579228 A	26/11/96	US 5558350 A		24/09/96